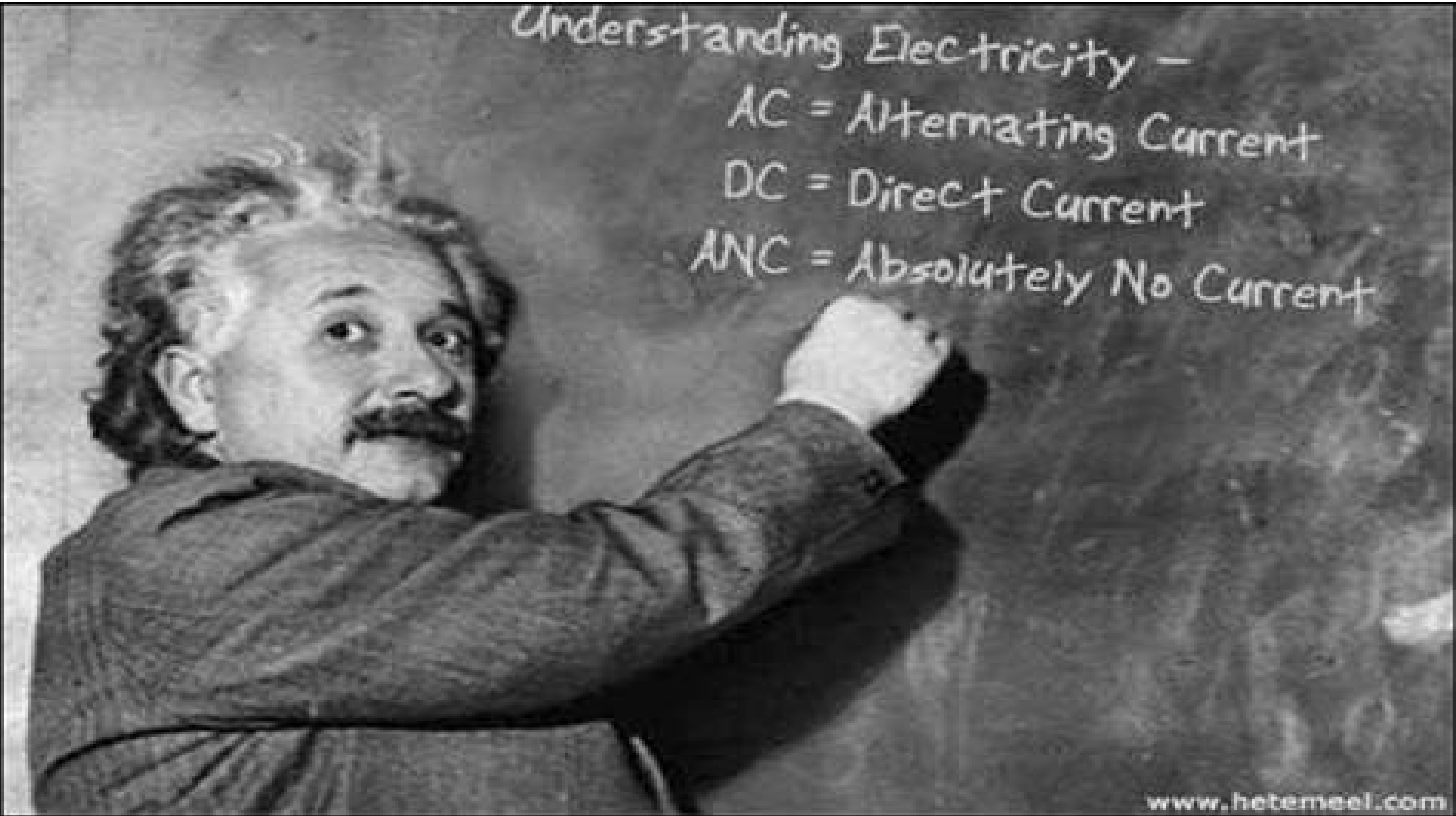

Understanding Electricity –
AC = Alternating Current
DC = Direct Current
ANC = Absolutely No Current
www.hetemeel.com

FLUOROSCOPY AND DIGITAL FLUOROSCOPY EQUIPMENT

Learning Outcomes

- **Explain** difference between fluoroscopic examinations compared to static examinations.
- **Discuss** the standard fluoroscopic imaging chain components.
- **Discuss** the basic components of the image intensifier (II).
- **Discuss the use** of flat-panel technology in fluoroscopy.
- **Advantages** of digital fluoroscopy systems.
- **Explain** purpose of filtration in modern fluoroscopic imaging chain.
- **Discuss** automatic exposure rate control.

Learning Outcome

- **Discuss** image quality in Fluoroscopy.
- **Discuss** the different modes of fluoroscopy operation.
- **Discuss** image processing including interlacing.
- **Advantages** flat panel compared image intensifiers.
- **Discuss** direct and indirect flat panel conversion modes.
- **Define** flux gain, quantum efficiency, detective quantum efficiency.
- **Discuss** radiation considerations in Fluoroscopy.

Sources

- Bushberg, J.T., Seibert, J.A., Leidholdt, E.M. & Boone, J.M. 2020. The *Essential Physics of Medical Imaging*. Fourth Edition. Philadelphia: Lippincott Williams & Wilkins. ISBN: 9781975103224.

  Chapter 9: Fluoroscopy

- Bushong, S. C. 2013. *Radiologic science for technologists: Physics, biology, and protection*. Tenth Edition. St. Louis, Missouri: Elsevier. ISBN: 9780323081351

  Chapter 25: Fluoroscopy

Do you remember

- What how we get from voxel to pixel using CCD and DR?
- Discuss the basic operation of an x-ray tube components?

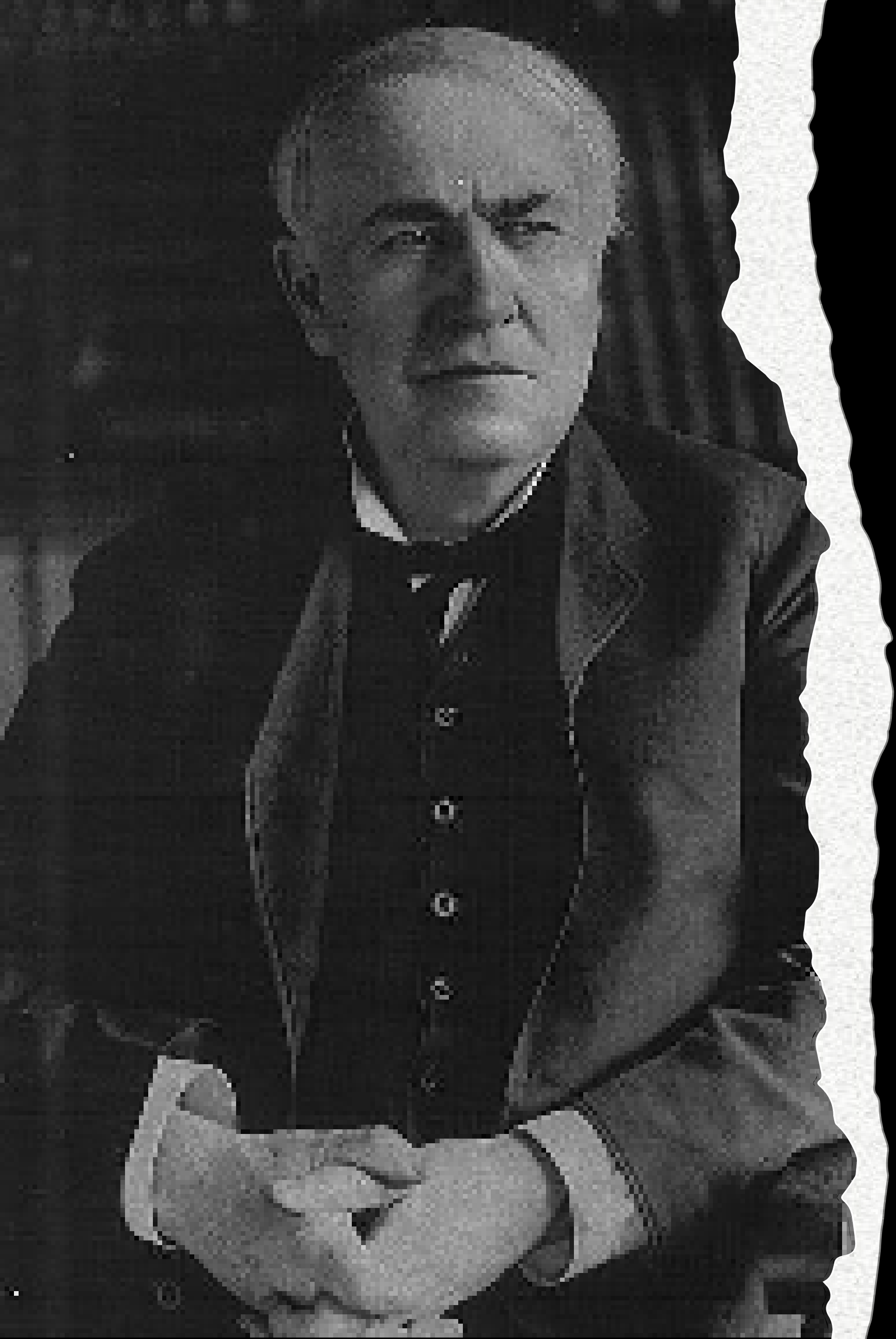


Figure 36-1

Historical "open fluoroscopy" involved watching a large intensifying screen placed behind the patient, without an image intensifier. This placed the operator directly in the x-ray beam.

This system had two major disadvantages:

- First, the **image on the screen was extremely dim** and required all the lights to be turned off in the room.
- Second, it resulted in very **high radiation exposure** to both the patient and the operator

Image intensifier (II)

- Fluoroscopic image intensification provides **dynamic real time imaging** in which the physiological function of an organ can be observed.
- Various gastrointestinal organs can be observed with the use of contrast media.
- **Static images** generally referred to as **spot views** can also be obtained digitally.

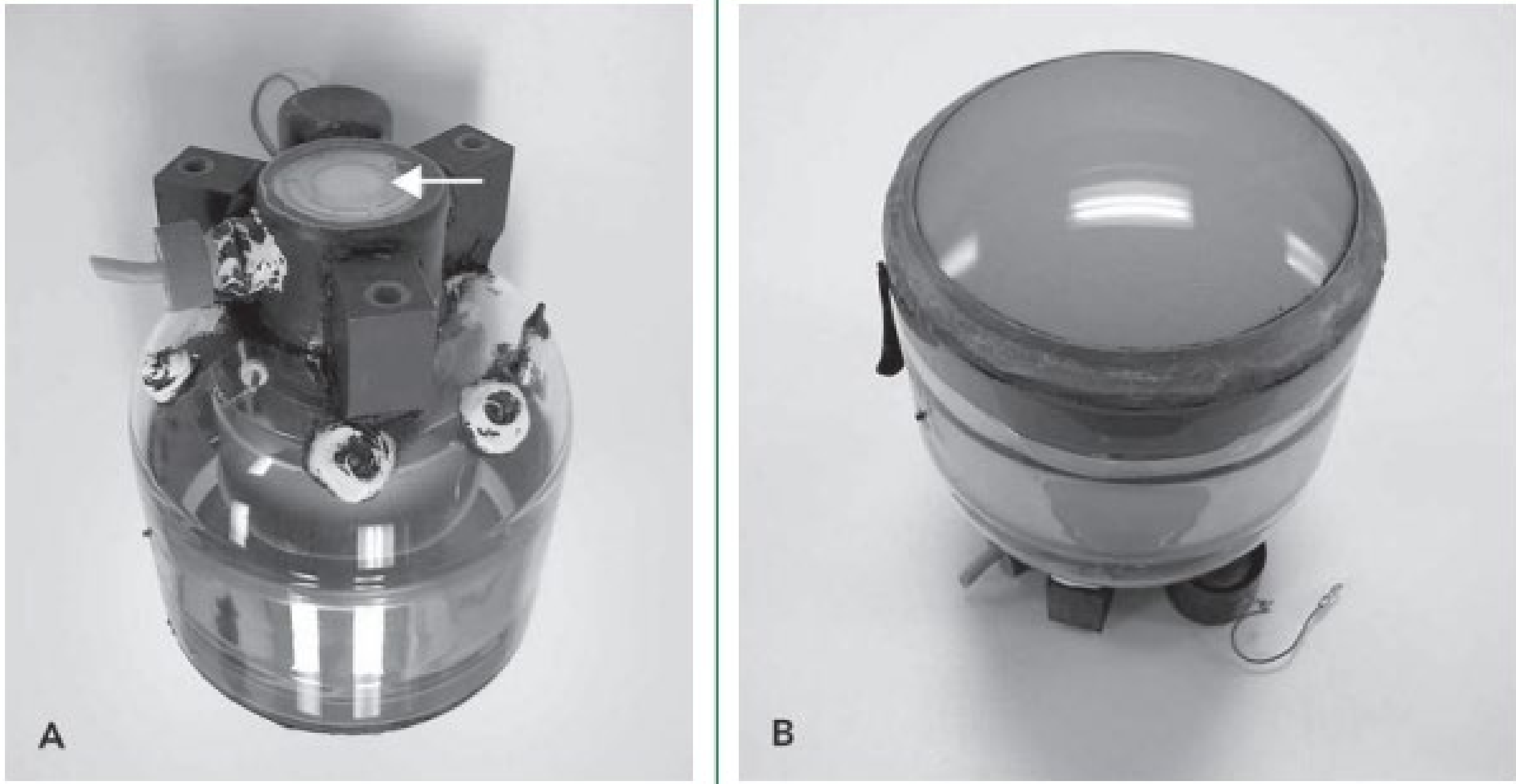
Fluoroscope

Image intensifier and Flat panel detector

- The **II has increased in size from the early 15-cm** (6-inch)-diameter **field of view (FOV)** systems to **40-cm (16-inch) systems available today.**
- Analog television (TV) cameras have been replaced with **high-resolution**, **low noise**, **digital charge-coupled device (CCD**) or **complementary metal-oxide semiconductor (CMOS) cameras**.
- Flat panel detector technology has led to **larger rectangular FOV** systems (e.g. 48 cm) with **high spatial resolution and improved image fidelity**, and will **gradually replace II detectors**.

Image intensifier (II)

Figure 36-3

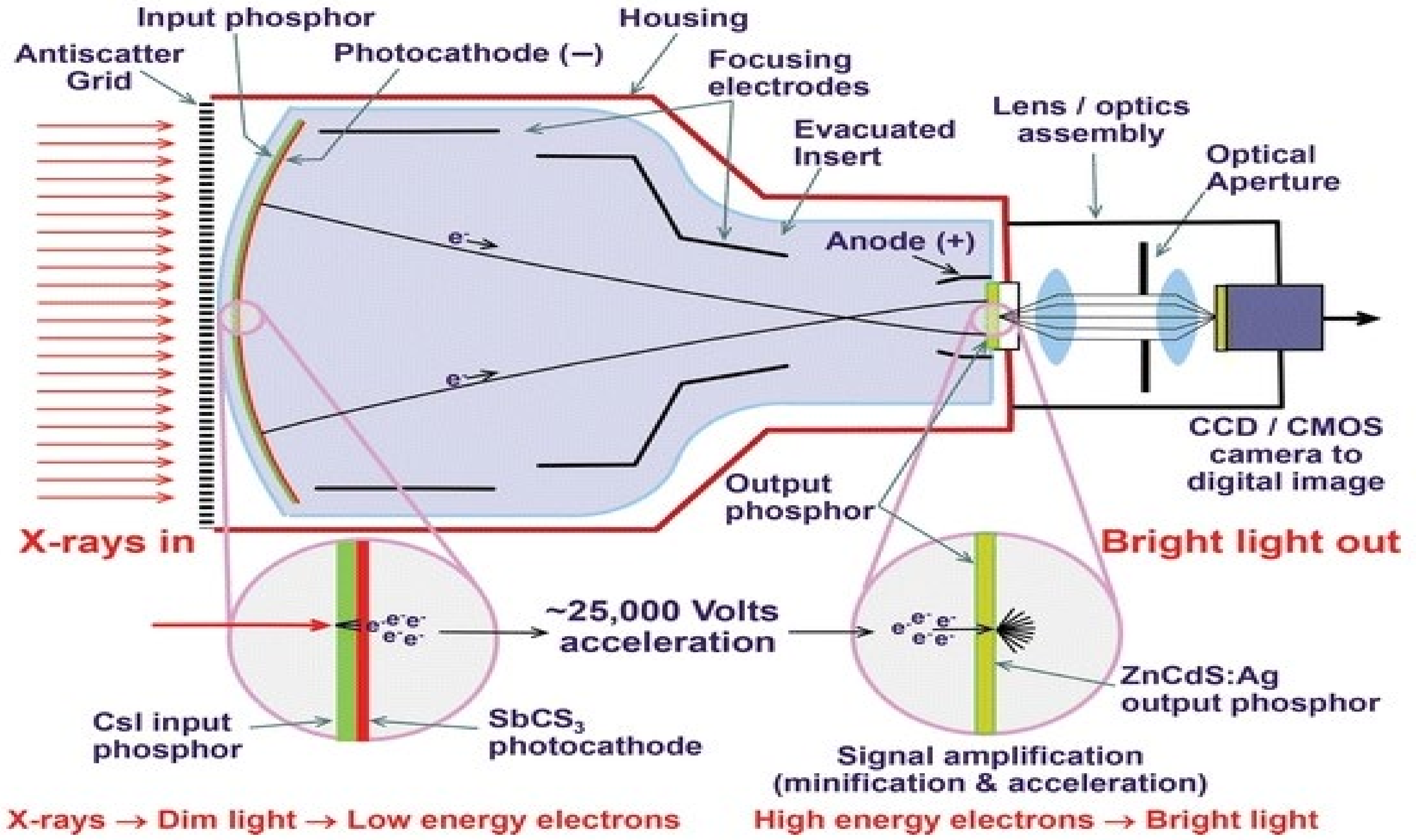


Photographs of an image intensifier tube, showing the output phosphor, *A* (arrow), and the input phosphor, *B*.

Basic components of the II

- The image intensifier tube is an evacuated glass envelope, a vacuum tube that contains five basic parts.
  1. the **input phosphor**,
  2. the **photocathode**,
  3. **electrostatic lenses**,
  4. the **accelerating anode**, and
  5. the **output phosphor**,

Image intensifier (II)



1. Input phosphor

- The **input phosphor** of a modern image intensifier is **a layer of microscopic needle shaped crystals of Cesium iodide (CsI)** which are packed tightly together.
- These are **fluorescent phosphors which transform the remnant radiation coming out of the patient into light**.
- The light emitted is in the **yellow-green wavelength**.
- The **columnar shape** of the crystals helps **prevent dispersion** of the emitted light to preserve resolution.

2. Photocathode

- The next active element of the image-intensifier tube is the **photocathode**, which is **bonded directly to the input phosphor with a thin, transparent adhesive layer.**
- The photocathode is a thin metal layer usually composed of **Cesium** and **Antimony compounds** that **respond to stimulation of input phosphor light by the emission of electron.**
- This process is known as **photoemission (**Photoemission is electron emission that follows light stimulation).

3. Electrostatic focusing lens

- The electrostatic focusing lenses are not really lenses at all, but **negatively charged plate** along the length of the image intensifier tube.
- These **negatively charged plates repel the electron stream**, **focusing it on the small output phosphor**.
- This process of focusing the electrons onto the output phosphor is called **minification**.
- Since the **light image at the output screen is reduced in size**, the **electrons are concentrated onto the much smaller screen**, so the **screen glows more brightly.**

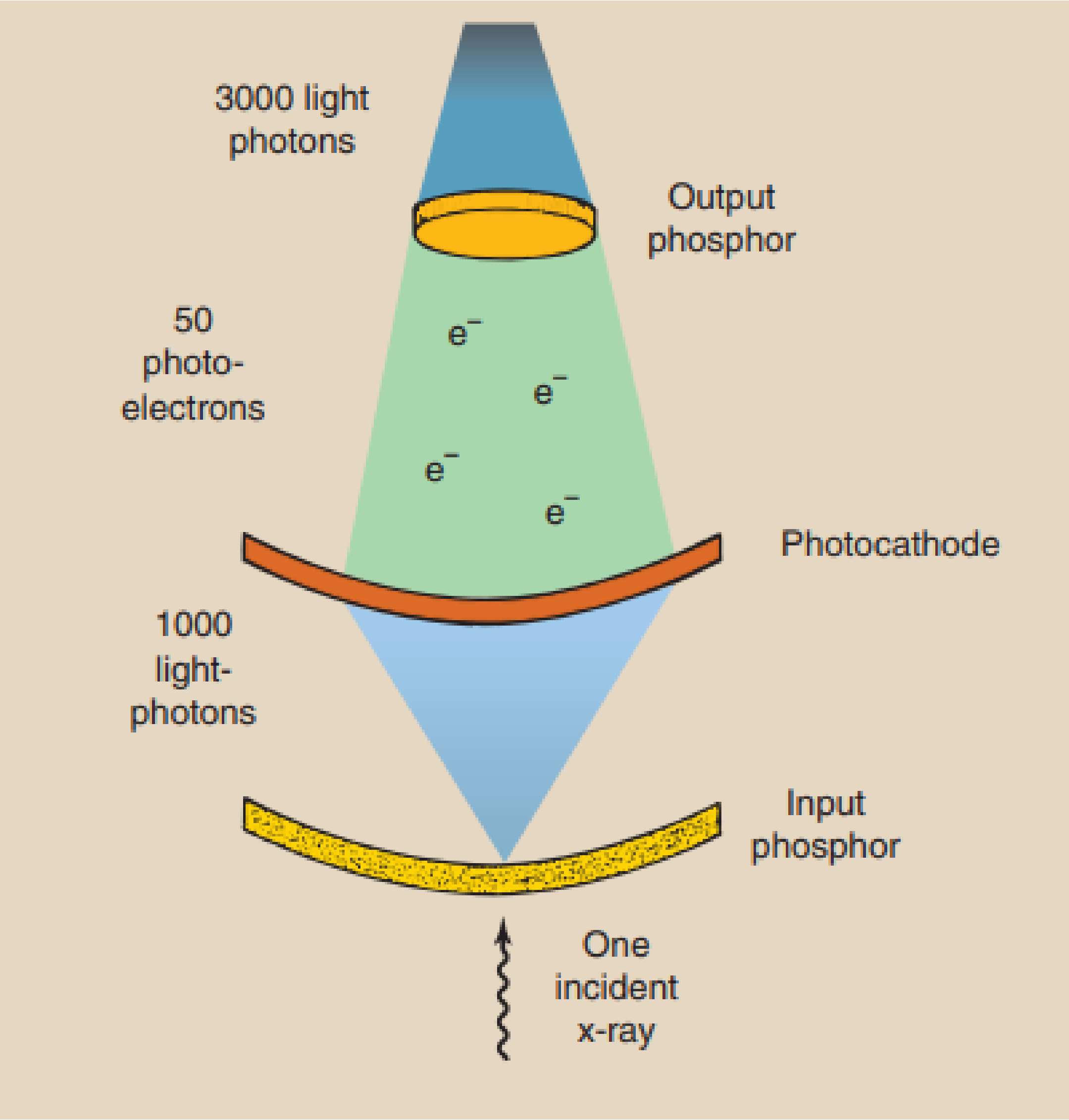


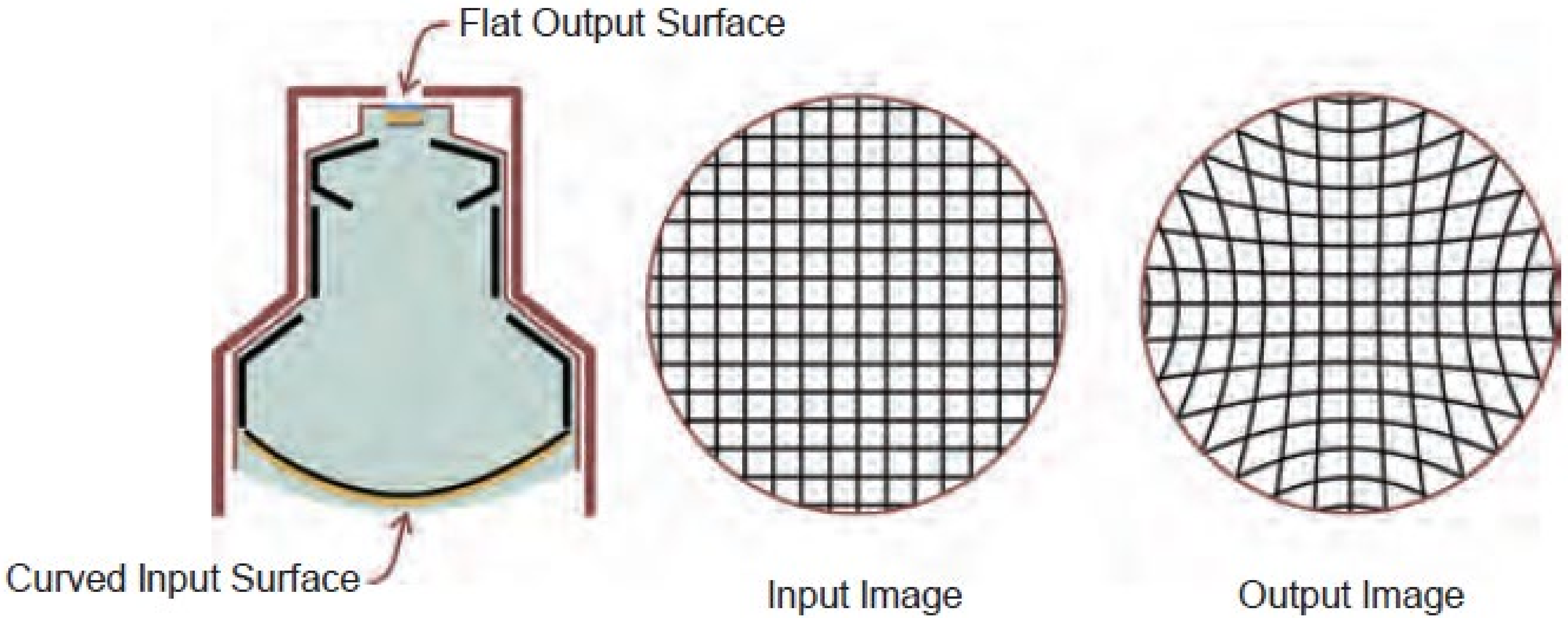
FIGURE 25-7 In an image-intensifier tube, each incident x-ray that interacts with the input phosphor results in a large number of light photons at the output phosphor. The image intensifier shown here has a flux gain of 3000.

4. Accelerating anode

- Located at the neck of the image intensifier tube (Fig. 36-4), the function of the accelerating anode is to attract the **electrons from the photocathode and accelerate them toward the output screen.**
- The **accelerating anode** is a small ring of metal, which has a **positive charge of 25,000-30,000 volts.**
- With this **tremendous positive attraction to the anode**, the **electrons accelerate and strike the output phosphor with 50 to 75 times more kinetic energy than they left the photocathode with**, all of which will be **transformed into light**

5. Output phosphor

- The output phosphor of the image intensifier tube is made of **Zinc Cadmium Sulfide**.
- When the electrons interact with the **Zinc Cadmium Sulfide** phosphor their **kinetic energy is transformed into light**.
- Since the output phosphor is typically only **1 inch in diameter**, the **light emitted from it is very concentrated and bright**.
- This **light then passes to the television camera tube or CCD.**


Flat Output Surface
Curved Input Surface
Input Image
Output Image

Flux gain

- This **ratio of the number of light photons at the output phosphor to the number of x-rays at the input phosphor is the flux gain.**

Flux Gain

$$\text{Flux gain} = \frac{\text{Number of output light photons}}{\text{Number of input x-ray photons}}$$

Brightness gain

- The **increased illumination of the image** is attributable to the **multiplication of light photons at the output phosphor** compared with x-rays at the input phosphor and the image minification from input phosphor to output phosphor, which is called **the minification gain.**
- The **ability of the image intensifier to increase the illumination level of the image is called its brightness gain**.
- The brightness gain is simply the **product of the minification gain and the flux gain**.

Brightness Gain

$$\text{Brightness gain} = \text{Minification gain} \times \text{Flux gain}$$

Minification Gain

- The minification gain is the **ratio of the square of the diameter of the input phosphor to the square of the diameter of the output phosphor**.
- **Output phosphor size** is fairly standard at **2.5 or 5 cm**.
- **Input phosphor size varies from 10 to 40 cm** and is used to identify image intensifier tubes.

Minification Gain

$$\text{Minification on gain} = \left(\frac{d_i}{d_o}\right)^2$$

where d_i is the diameter of input phosphor and d_o is the diameter of output phosphor.

Question - Classwork

- Calculate the brightness gain of a 17-cm image-intensifier tube with a flux gain of 120 and a 2.5-cm output phosphor?
- Show workings [3]

Brightness Gain

Brightness gain = Minification gain × Flux gain

Flux Gain

$$\text{Flux gain} = \frac{\text{Number of output light photons}}{\text{Number of input x-ray photons}}$$

Minification Gain

$$\text{Minification on gain} = \left(\frac{d_i}{d_o}\right)^2$$

where d_i is the diameter of input phosphor and d_o is the diameter of output phosphor.

(**ANSWER: 5549**)

Conversion factor

- **Brightness gain** is now defined as **the ratio of the illumination intensity at the output phosphor,** measured in candela per meter squared (cd/m^2) to the radiation intensity incident on the input phosphor, measured in milligray per second (mGya/s).
- This quantity is called the **conversion factor and is approximately 0.01 times the brightness gain.**
- The **conversion factor is the proper quantity for expressing image intensification.**

Conversion Factor

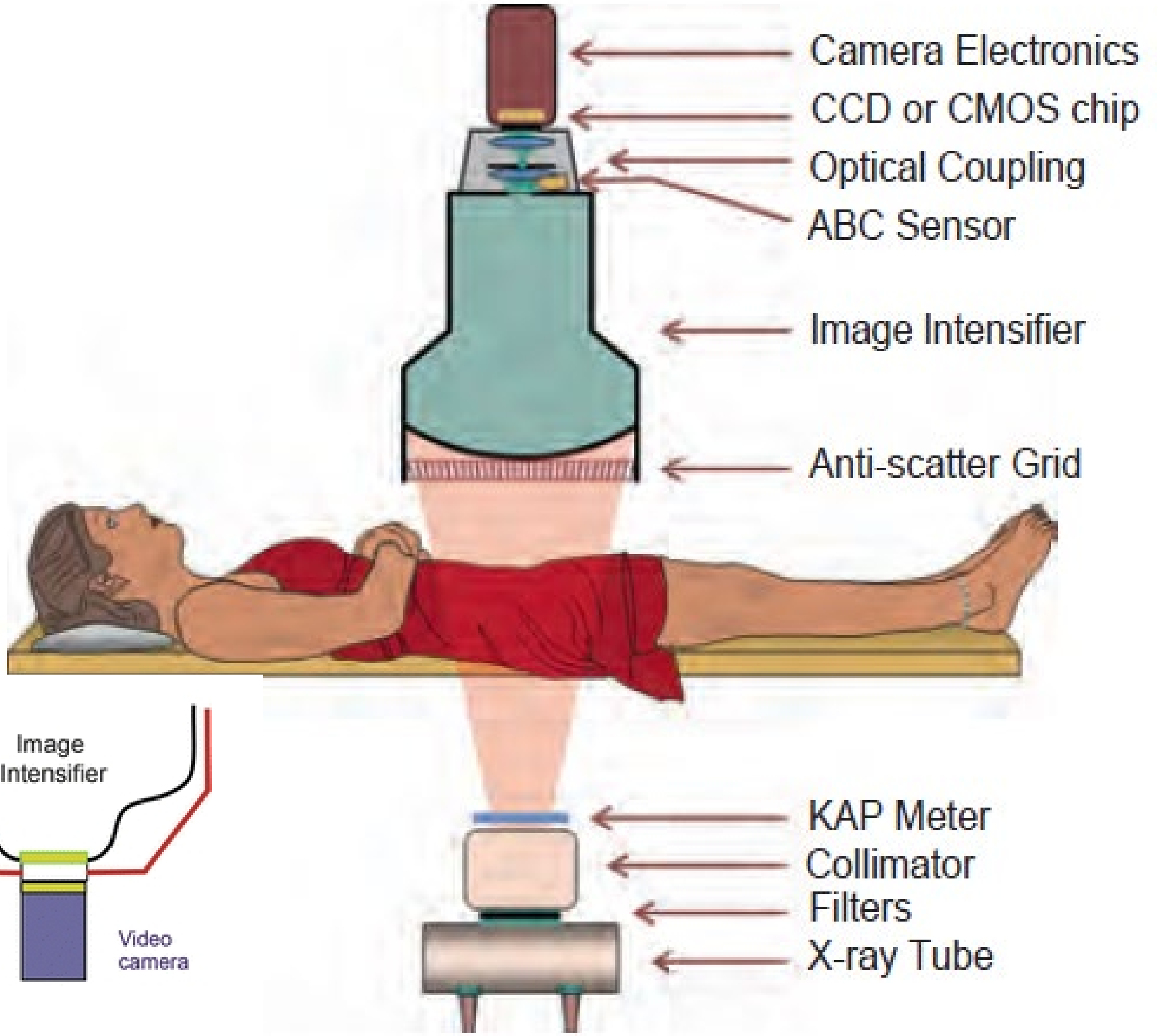
Conversion factor

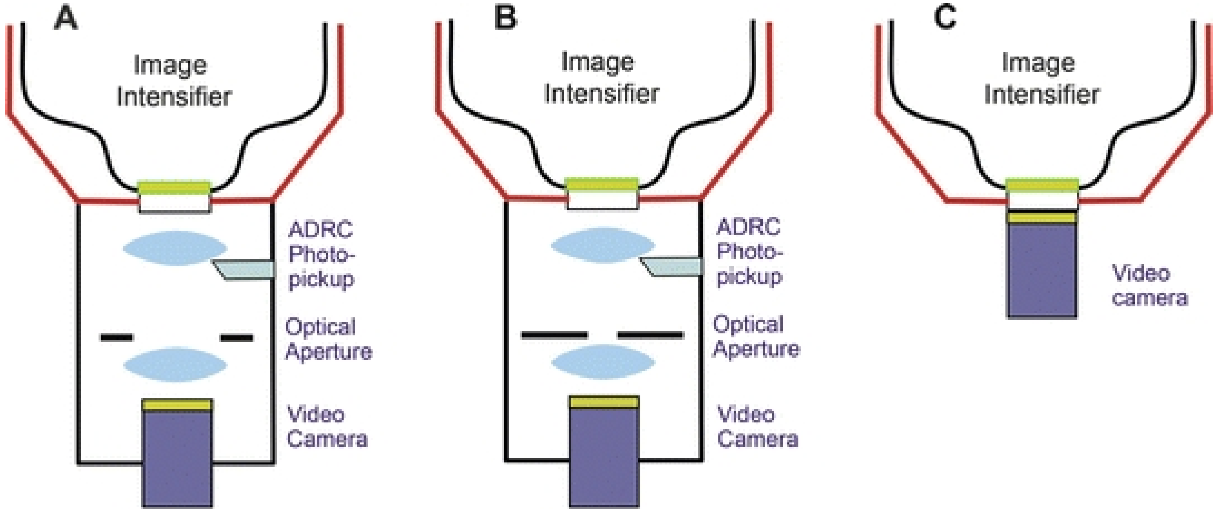
$$= \frac{\text{Output phosphor illumination } (\text{cd/m}^2)}{\text{Input exposure rate } (\text{mGy}_a/\text{s})}$$

mGy_a/s

Video camera

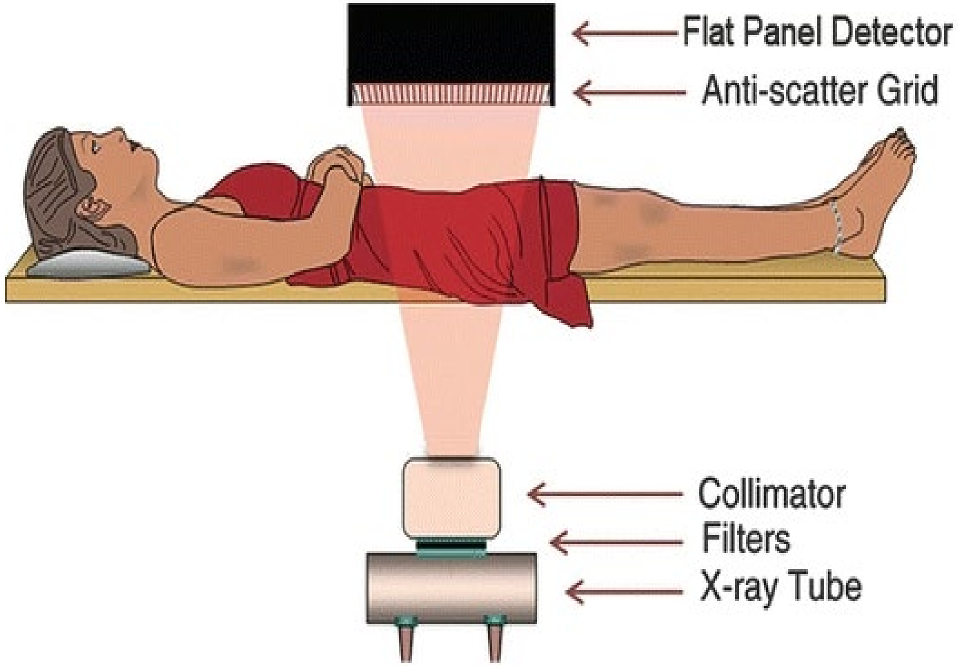
- CCD/ CMOS
- Photo detectors

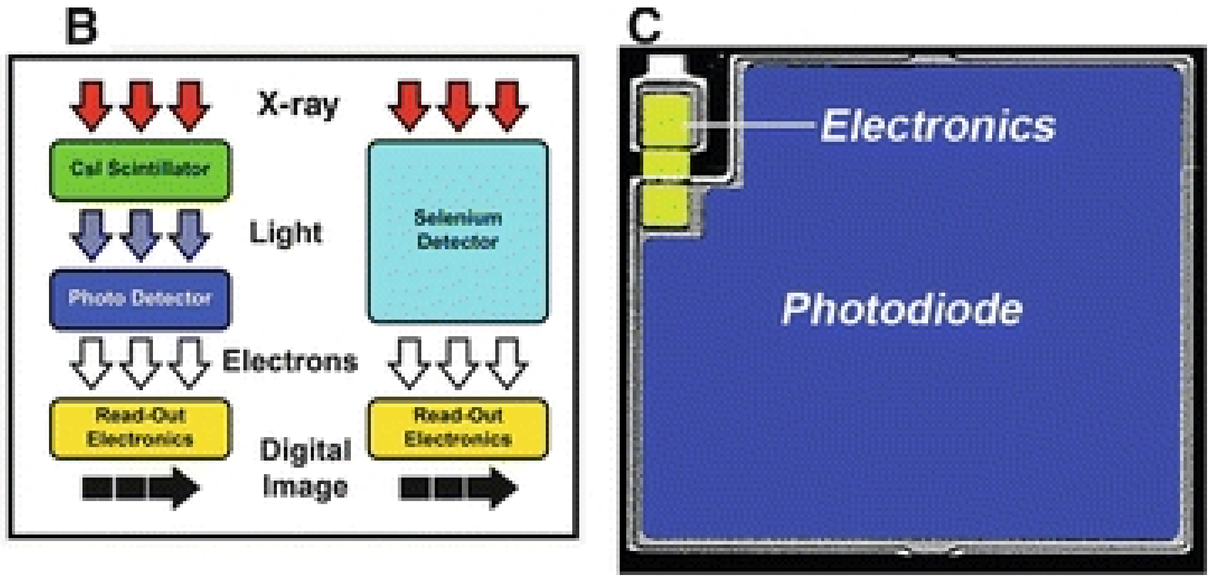




DR

- Indirect/ Direct





DR

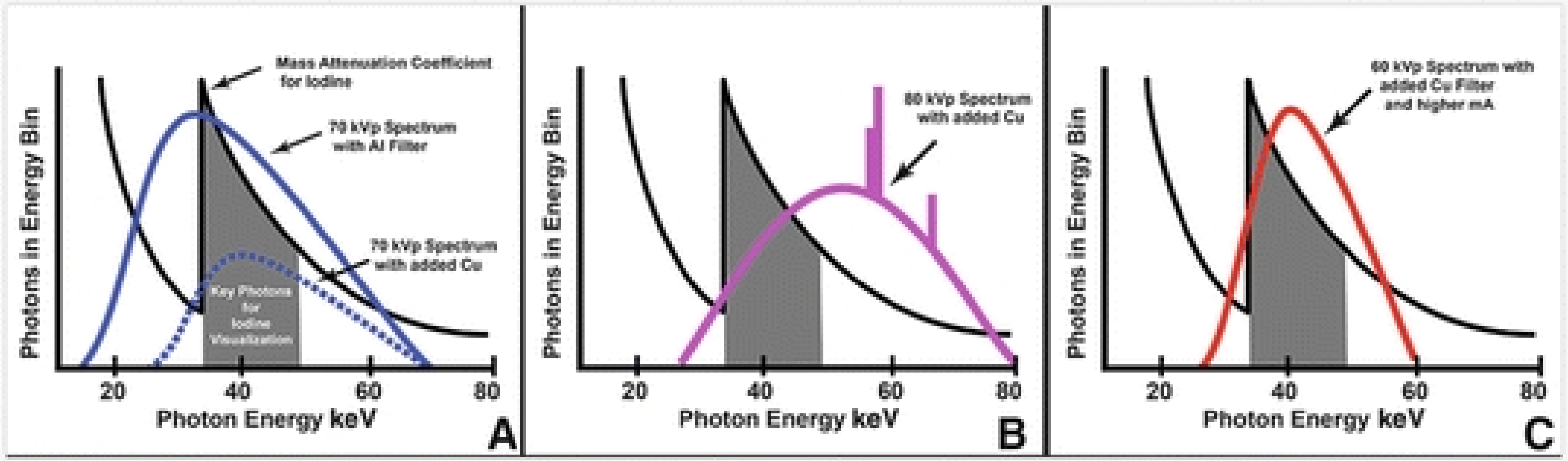
- Dexels vs pixels
- Improves spatial resolution
- FOV- Subarray
- Binning

Requirements of tube- SS

Collimation AND Spectral shaping

- FOV Set by operator/ change in SID
- Limits
- Improves safety and image quality

- Contrast media
- Needs to be absorbed



AERC

- Less dens to more dens
- Lungs vs mediastinum
- Automatic control of exposure